An Eskimo family at Hopedale, Labrador. From a photograph.

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THE RELATIONS OF MIND AND MATTER.

BY CHARLES MORRIS.

I. THE THREEFOLD NATURE OF EVOLUTION.

AT what level in nature does consciousness first come definitely into existence? This is one of the most difficult of the problems of science, and one which, perhaps, can never be clearly answered. At the limiting boundary of conscious and unconscious action it is quite impossible to tell, by any means at present at our command, whether blind force or intelligent agency is at work. Even within our own bodies it is difficult to limit the kingdoms of consciousness and unconsciousness, and equally difficult to decide that actions which seem now wholly unconscious were originally so. This question cannot always be decided by the claim that here reason has evidently been at work, and there only natural selection. For the results of reason and natural selection, as applied to the modification of the body and of its habits, are singularly alike. In each case adaptation to external conditions is produced, and there can be only certain definite adaptations to each limited set of conditions. Thus if the results of two energies are of precisely the same character, it is impossible to decide from these results which energy has been active. Where the change has been too rapid for the powers of natural selection, we may be sure that consciousness has been at work. But in the case of very deliberate changes we cannot positively decide to which force they are due, and some degree of conscious action may extend to a much lower level in the realm of nature than we usually imagine. On the other hand natural selection may be the sole active agency up to a somewhat high level.

Evolution has its three distinct and dissimilar phases, on each

of which natural selection acts, though it is customary to apply this principle to only the second of these phases. These are the chemical, the functional and the psychical. So far as organic evolution is now concerned, chemical development has become of minor importance. Yet originally it was of supreme importance. In fact, the whole vast range of inorganic chemical development was a necessary preliminary to organic existence, and constituted the primary phase in that grand whole of evolution which is a continuous and not a broken chain.

Very probably, in the primeval period, inorganic chemism yielded far more complex compounds than any it now presents. The conditions of temperature at that period, and the fluid state of many elements which are now found only as rigid solids, must have aided such a chemical activity. Even now more complex compounds than we find would doubtless exist but for a reason to be considered further on. This primeval chemical evolution may have gone on for ages without impediment, yielding steadily higher and more complex products, every fixed stage of which formed the basis for a new upward step of material development, until finally a stage approximating to that of protoplasm was reached. But long before this stage was attained, it is highly probable that functional evolution came into play, and at once acted as a check to the rapid progress of chemical development. As soon as an unstable colloid compound was thus produced, so constituted as to be subject to the disintegrating attacks of oxygen, self-motion of such matter may have begun, and the long reign of functional activity originated. This is all we find in functional life now, the self-motion of unstable colloids through the action of the energy set free by oxidation, and it is quite probable that such activity began as soon as a primeval colloid, of suitable constitution, was produced.

But chemical evolution could not have ceased with this first appearance of functional action. It must have long continued, yielding products of higher and higher complexity, and more susceptible to the function-producing influences, until finally the excessively mobile compound now called protoplasm originated. Yet there can be no doubt that with the earliest appearance of functional activity a check was placed upon chemical development. This check grew more vigorous as functional action became more unfolded. Finally a practical limit to the increase of chemical

integration was reached, and functional activity took its place, as the second great agent in evolution. Yet this check to chemism could have been by no means completed with the first appearance of active living forms. Superior and more susceptible proteids may have continued to appear, perhaps to the very borders of the present time, rendering the operation of functional change more and more active and capable. There is certainly good reason to believe that the protoplasmic basis of all beings is not identical, and if so, that chemical evolution may have continued, with ever-decreasing efficiency, throughout the whole long period of organic existence. As for the utter disappearance of the link forms between protoplasm and the highest existing inorganic compounds, it is no more surprising than the similar disappearance of so many of the link forms of life. They have been crowded out of existence by natural selection. Protoplasm doubtless has its embryology, whose steps, if we could trace them all, would lead us to a knowledge of its phylogeny. Many of the high-atomed products which successively appear in the development or during the disintegration and decay of organisms may be identical with primeval compounds which preceded protoplasm. Yet all of these have their enemies in the vast and varied hosts of fungi which depend upon them for nutriment. They no sooner cease to be protected by the energies of active life, than they are assailed and partly reduced to simple inorganic conditions, partly become food for fungi.

We can readily conceive, then, that were high-atomed chemical compounds now formed from the elements, by inorganic agency, they would in all probability be at once attacked by fungi, and consumed as nutriment or disintegrated. The incessant activity of the fungoid organisms places a definite check on any high inorganic evolution under present conditions. Yet, as above said, in the existing formation of protoplasm, its phylogeny is indicated precisely as the ancestral forms of the higher animals are indicated in their embryological development. Many of the steps may be slurred over in the one case as in the other, and in the formation of protoplasm by the plant, through successive integrations, from carbonic acid, water and ammonia, we may have a greatly shortened and masked preservation of the original steps of the development of protoplasm from the inorganic elements. The time may come when the human form can be phylogeneti-

cally traced, not only to the rhizopod, but to the chemical elements.

The second great phase of material evolution, the functional, which has gradually unfolded until, from forms lower than the rhizopods—mere homogeneous masses of protoplasmic molecules—it has produced the extraordinarily intricate and heterogeneous form of man, as the highest existing stage of material combination, is due to the operation of two characteristics inherent in protoplasm. The first of these is the power of self-movement, through the agency of internal energy set free by oxidation. The second is the power of inducing new chemical action to the production of new protoplasm. The mode of operation of this second agency is as yet in great part a mystery. But that it exists is too evident to be for a moment questioned. And there is considerable reason to believe that these two agencies do not act simultaneously, but that oxidation of protoplasm and reintegration of the same are always successive processes in the organic economy.[1]

At some period in this long process of organic development there came into operation a third distinct phase or process of evolution, the psychical or mental phase. It is this with which we are here alone concerned. Its appearance and unfoldment seem related to functional action as the latter is to chemism. Psychical action has constantly tended to check functional variation, and to replace it by a new controlling agency. As organic action slowly checked the development of chemism, and at last wholly or nearly superseded it, so psychical action has opposed the energy of functional variation and, in the case of man, has largely superseded it. The three modes of energy here indicated are probably all due to the action of forces inherent in the constitution of matter, and some of the conditions of this action are very evident. These it may not be amiss to briefly indicate.

Every mass of matter, however composed, is constantly affected by two sets of forces, those acting internally and tending to preserve and increase its complexity of organization, and those acting upon it from the external world and tending to reduce or destroy its complexity. In chemical integration the internal energy is in the ascendant. The compound is formed by the innate forces of its elements, and grows more complex through

[1] See The Organic Function of Oxygen, AMER. NAT., Feb. and March, 1883.

the continued activity and supremacy of these forces. Yet all such compounds are constantly subject to the action of external forces, and are occasionally disintegrated or otherwise affected thereby. The more complex the compound the more exposed is it to the disturbing influence of external energy. At the same time the more complex the chemical compound, the less vigorous is the action of the innate energies of affinity. It is evident, therefore, that at some point a balance between these opposed energies must be reached. While chemical energies continue superior there must be a gradual increase in the complexity of compounds, despite the assaults of external energy. But when these opposing energies become definitely equal in vigor, it seems evident that a fixed status must result. There may be upward and downward swings, as one or the other agency gains a temporary supremacy, but the general level cannot permanently be departed from.

Such is apparently the chemical status of protoplasm. It indicates the level of balance between internal and external energies. If it be broken down by a vigorous influx of external energy, the activity of chemical energy becomes superior, and reintegration sets in until the balance of forces is again attained. Chemism cannot go further and produce a stable compound of higher complexity. Yet there is good reason to believe that unstable compounds of this high character are frequently produced, molecules lifted above the general level, and therefore liable to break down instantly at the least influx of external energy. It is probably to the existence of such excessively complex molecules that the high sensitiveness of nervous and muscular tissue is due. Lifted too far above the level of harmony of the forces, they break down at a touch.

Other results follow. Motor forces are set free within the tissue which give it self-motion. This self-motion brings it into new relations with external substances, and other changes than purely chemical ones follow. Variations in form and constitution in response to these external influences take place. Natural selection upon function and form comes into play, and the organism that resists the adapting influence of external energy ceases to exist. Only those mobile organisms that readily yield to the molding influence of external energy, and closely adapt themselves to the conditions of nature continue to exist. Thus in the

chemical phase of evolution internal energy is in the ascendant and controls the results. In the functional phase chemical energy merely holds its own, and a fixed molecular status is gained. But external energy acts upon tissue as a whole, and produces definite variations in form.

If we now come to consider psychical evolution we find it still to be a question of the interplay of internal and external energies. Reference here is made to its purely physical results, and not to its important characteristic of consciousness. In the growth of psychical conditions we still have to do with the external energies which play upon the body and force their way into it over the channels of the nerves. But as the body improves in its sensory organization, and permits the ready inflow of external energy, the balance between the two series of energies is broken, external energy becomes in excess and there is a tendency to break down the molecular complexity of the body to a lower level. Could all those inflowing energies play upon the muscles a fixed fall in the chemical level must succeed. As it is, however, these energies are checked in their inflow. The muscles are permitted to receive no more than they are prepared to accept. The remainder are restrained in their action to the cerebral ganglion, where they exert an organizing influence upon some substance whose character is as yet a problem. This is the third or psychical phase of organic evolution.

The motor energies, thus drafted off into this cerebral substance, there combine into a congeries of forces of yet unknown character, which we call the mind. It has two characteristics. The energies which constitute it are persistent. And they enter into new combinations which have no counterpart in external nature. It constitutes a new center of force which in its turn acts upon the body and aids in molding it. External forces are no longer supreme. A reservoir of internal energy has been formed which frequently acts in opposition to them. And one of the most essential characteristics of the action of this mental center of force is, that its activity is not exhausted upon the body. In fact it finds an important field of action in the external world. It molds nature as well as the body. In place of the organism needing to adapt itself to external conditions, it acts to adapt external conditions to itself, and its own need of change is obviated to the extent that it acts upon and remodels the world without.

All the numerous products made by man, his clothing, habitation, tools, &c., and all the changes in the conditions of nature produced by his agency, are results of this third phase of evolution. Functional change is forced upon the external world, and to that extent ceases to act upon the body. Harmonious adaptation continues necessary, but nature is made to adapt itself to man, and man has little need to adapt himself to nature. It is not, however, a simple reaction, through the body, of external forces upon external nature. A reaction of this kind exists throughout organic life. Every motion of an organism in direct response to the impulse of external influence exerts an influence upon external nature. But as a rule it produces no new conditions. Adaptation is mainly confined to the body. In psychical action, however, new conditions are produced. The energies which have flowed into the cerebral reservoir are there recombined into new aggregates, or ideas, as we name them. These, in their reaction upon external nature, produce new conditions, embodiments in matter of new relations of energy, and the substances external to the body are forced to adapt themselves to the needs of the organism.

This psychical reaction upon external nature is not a common characteristic of animal action. It is specially active in man, and presents a considerable activity in some of the lower tribes, as the beavers, the ants and the bees. But in the great majority of animals it is almost non-existent. Very few even of the higher vertebrates make any effort to adapt nature to their needs, but accept existing conditions. In such cases all the molding action of energies must be exerted upon their bodies, and such adaptation as becomes necessary must be confined to the organism.

Yet psychical action in these lower animals is not without its special results, distinct from those yielded by the direct action of external energies. It yields rapid variations in the habits of the animal, adapted to particular cases, and which often enable it to survive where otherwise it would perish. These may be special movements in flight or combat, new modes of concealment, the display of cunning in non-habitual manners, and the like. In fact, in the difficulty of deciding whether any animal is influenced by mental energies or not, we are in great measure dependent on the occurrence of unusual actions, adapted to special situations. If actions are habitual they may be unattended by con-

sciousness, even though they seem to display the utmost accuracy of reasoning. Natural selection yields results so closely analogous to those of reason that it is almost impossible to discriminate between them, and in fact quite impossible except where a change of habits is displayed too great and sudden to be possibly due to the action of unconscious agencies on the slight congenital variations in animal forms.

In attempting to decide, then, at what level of life consciousness comes into definite existence, we are met with this difficulty. Actions of the most intricate character, such as many of those performed by the ants, for instance, are not beyond the conceivable powers of natural selection if they have been for very many generations practiced, with extremely slow variations, by one species. Yet ants adapt nature to their needs, and thus counteract the action of physical conditions upon their bodies. Therefore that phase of activity which we have above considered specially significant of psychical agency—the remodeling of external conditions—seems to be not beyond the scope of natural selection, and only where the adaptation is individual instead of tribal, and rapid instead of gradual, can we be sure of its psychical origin.

If, for example, we consider the great kingdom of vegetable life, there are abundant reasons to believe that, in all of its higher manifestations, at least, it is devoid of consciousness. And yet its adaptations to the conditions of nature are often so complex and extraordinary that it seems almost incredible that they could have arisen without the aid of reason. Only the unpitying energy with which nature weeds out all illogical adaptations can explain the logical consistency of those that persist. If the habits of an animal change in response to logical reasoning, this change must be in the direction of exact adaptation to nature. But the same end is achieved by the blind but vigorous agency of selection, which is utterly merciless to the ill-adapted. If we could imagine plants to be suddenly given the power of motion, and thus brought into new and more varied relations to nature, it is evident that their adaptations might become yet more intricate, and still more like the results of intelligence and judgment, though gained through the action of unconscious influences. In such a case they might readily rival many of the lower animals, and unconsciously perform actions closely analogous to those which it

is usual to ascribe to consciousness. In fact, the plant world is not utterly destitute of such motor powers. The mycelium of the Myxomycetes so closely simulates the Amœbæ in its motions that it is difficult or impossible to distinguish it from the latter. Yet it is but a plant in motion, and is undoubtedly unconscious. Again the white blood corpuscles of animals are also indistinguishable from Amœbæ in character and habits; yet we can scarcely credit each of them with conscious life. At a higher level in plant life we again meet with motor powers. Thus the carnivorous plants display characteristics not unlike those seen in the polyps; yet they are unquestionably unconscious, and we might safely ascribe a similar unconsciousness to the polyps and all other animals of similarly low grade.

Thus if we begin at the lower levels of organic life, and trace nature upward in her development, it is very difficult to perceive where the influence of heredity and natural selection ceases to act and conscious choice enters into life as an element. On the other hand if we commence with the conscious life of man, and trace nature downwards, it is equally difficult to decide where consciousness ends. For at a certain intermediate level the phenomena observed might safely be ascribed to either conscious or unconscious action. Both seem capable of producing them, and it is utterly impossible to decide, with our present knowledge of the subject, which does produce them. Where there is evidence of unusual choice in some animal, or marked variation from its hereditary habits, we can be sure of conscious activity. On the other hand, where there is no nervous system, and no cerebral organ or force reservoir, we may reasonably question the existence of psychical powers. And yet, even in this extreme case, we cannot positively declare that consciousness does not exist. In fact, although we may imagine that we are considering two conditions of whose actual existence we have equal knowledge, such is really not the case. Man finds in himself his only standard of comparison. We know that within ourselves consciousness exists, and oversees, though it may not directly control, the great mass of our actions. We know, on the other hand, that many of our actions are performed unconsciously. In considering the activities of lower nature, then, we cannot actually know that consciousness may not, to some extent, accompany them. We have some warrant to say that the unconscious action, which

is exceptional with us, is the rule with them, but we can at no level positively declare, "here it is absolutely impossible that consciousness should exist." We must understand the subject far more thoroughly than now ere this question can be definitely decided.[1]

(To be continued.)

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KITCHEN GARDEN ESCULENTS OF AMERICAN ORIGIN. II.

BY E. LEWIS STURTEVANT, M.D.

(Continued from p. 457, May number.)

Jerusalem Artichoke.—Botanical analogies and the testimony of contemporaries agree, as we have seen, says De Candolle[2] in considering this plant to be a native of the north-east of America. It was introduced to England about 1617, as we learn from the second edition of Gerarde,[3] and this is nearly coincident with the first mention of this species in Europe, that by Fabio Colonna.[4] Lescarbot brought these roots into France about this time.[5] "Hartichokes" are mentioned as growing in Virginia in 1648,[6] and "artichokes" were cultivated at Mobile in 1775, but whether this plant or not, does not appear from the context.[7] They are mentioned by writers on American gardening from 1806 onward.[8] In Pennsylvania the tubers are yet raised by some and sent to the New York market, "they are disposed of for lunch purposes and there is a ready sale."[9]

Most interesting articles on the geographical and botanical history of this plant, by Messrs. J. Hammond Trumbull and Asa Gray, will be found in the *American Journal of Science,* May, 1877, and April, 1883.

Martynia.—Two species, *Martynia proboscidea* Glox. and *M. lutea* Lindl., occur in our gardens, the seed pods while yet tender

[1] See in this connection Cope, On Catagenesis, AMER. NAT., Oct., 1884.

[2] Orig. of Cult., Pl. 44.

[3] Herbal, 1636, 753.

[4] Ecphasis minus cognitarum stirpium, Rome, 1616.

[5] Hist. la Nouv. France, 1618.

[6] A Perfect Disc. of Va., Lond., 1649, 4.

[7] Romans, Nat. Hist. of Fla., I, 115.

[8] M'Mahon, 1806, Gardiner and Hepburn, 1818, as good for hogs and cattle, Fessenden, 1828, etc.

[9] Agr. of Pa., 1883, 358.